THE ROLE OF REACTANT TRANSPORT IN DETERMINING THE PROPERTIES OF NIF SHELLS MADE BY INTERFACIAL POLYCONDENSATION

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Polymer shells up to 2 mm in diameter were prepared using an interfacial polycondensation / cross-linking reaction occurring at the surface of an oil drop which is comprised predominantly of an organic solvent and a smaller fraction (10 wt% or less) of isophthaloyl dichloride, IPC. The reaction is initiated when the IPC-loaded oil drop makes contact with a pH~13 aqueous solution of poly(p-vinylphenol), PVP. It is the surface tension of the oil-water interface which drives the overall sphericity of the forming shell. During preliminary experimentation, it was found that the surface roughness characteristics of these shells did not meet those needed for viable National Ignition Facility (NIF) targets. Hence, the primary goal of this project has been to understand the evolution of the surface roughness in the PVP-IPC interfacial reaction process in order to be able to produce the smoothest shells possible. To determine the particular sources of the surface roughness, we focused on understanding the mechanism of shell wall growth and the role of reactant transport.

We determined the effect of IPC and PVP concentration, reaction time, oil-phase solvent (e.g., diethyl phthalate, 1,6-dichlorohexane, 4-chlorotoluene, etc.), and PVP molecular weight on both the shell thickness and surface roughness. Shells were characterized for roughness using SEM and AFM. Shell structure and other important processing parameters were assessed using a number of other techniques including FTIR, pyrolysis techniques, gas permeability measurements, and swelling measurements.

We have found that shell thickness is a function of acid chloride concentration and the oil phase solvent. We believe the ultimate wall thickness of the shell (at long reaction times) is determined by two competing reactions: diffusion of the diacid chloride through the forming shell wall (with non-stationary physical properties) necessary to react with the partially-deprotonated PVP at the surface, and diffusion of water into the oil drop through the PVP layer resulting in hydrolysis of the diacid chloride. We found that shell growth and the resulting properties are influenced strongly by the organic phase solvent. We believe this response is due to relative reactant / solvent permeability through the evolving polymer membrane.

**This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.